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(71) Applicant(s)

Siemens Aktiengesellschaft
(Incorporated in the Federal Republic of Germany)
Wittelsbacherplatz 2, 80333 Munchen,
Federal Republic of Germany

(72) Inventor(s)

Uwe Sydon
Juergen Kockmann

(74) Agent and/or Address for Service

Haseltine Lake & Co
Imperial House, 15-19 Kingsway, LONDON,
WC2B 6UD, United Kingdom

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None

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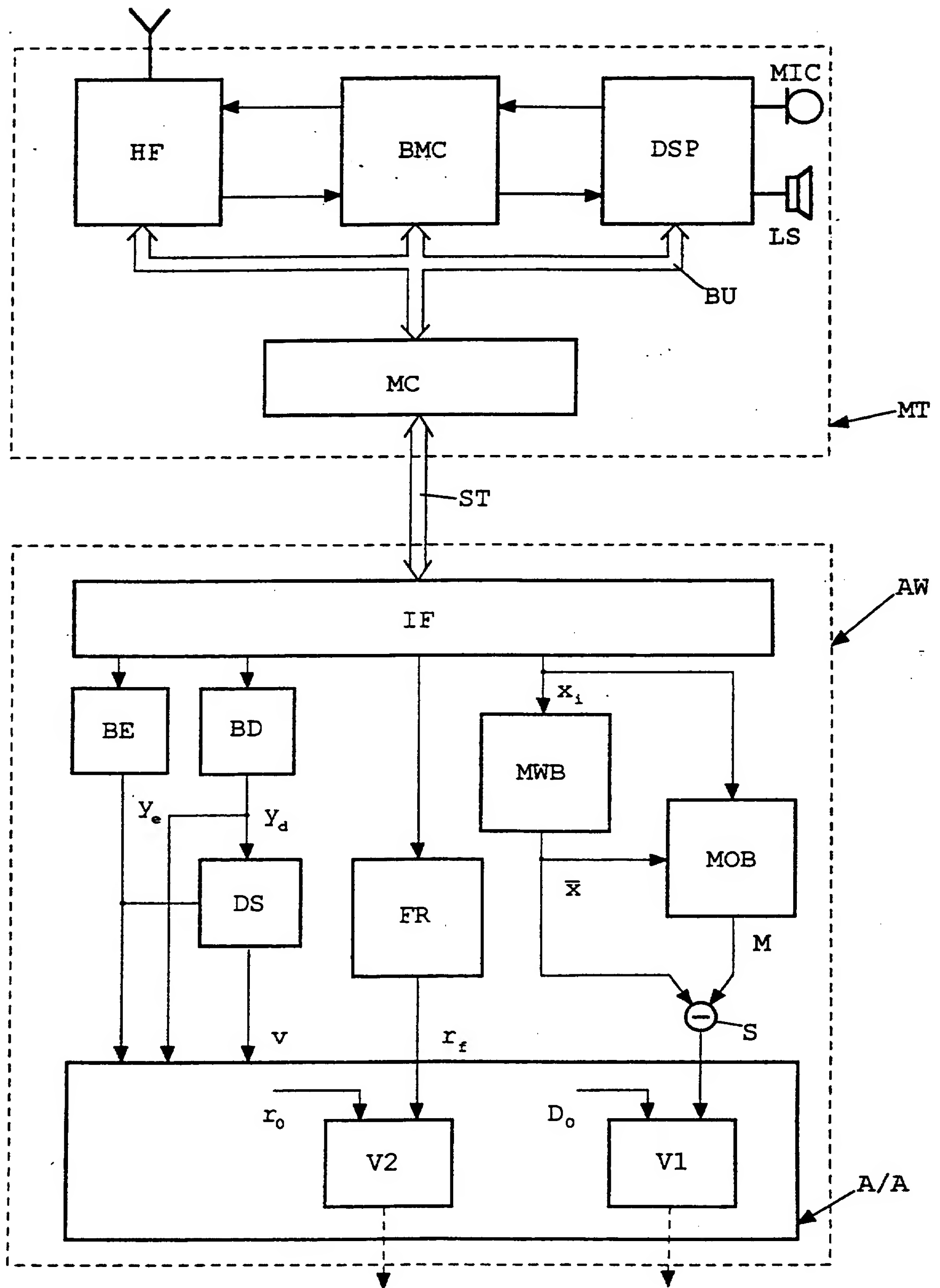
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(54) Abstract Title

Determining the Transmission Quality of a Radio Channel

(57) In a method for testing the transmission quality of a radio channel in a cell radio system having a TDMA structure, a mobile station (MT) periodically measures values (x_i) of the received field strength. An evaluating unit (AW) calculates from the field strength measured values an average field strength (x) and also the fourth moment (M) and establishes the difference (D) between the two. Depending on whether this difference is below a limiting value, the frame error rate is used as an additional quality measure.

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METHOD AND ARRANGEMENT FOR DETERMINING THE TRANSMISSION
QUALITY OF A RADIO CHANNEL

5 The invention relates to a method and an
arrangement for determining the transmission quality of
a radio channel between a base station and a mobile
station in a cell radio system in which the received
field strength is established. In particular, the
invention relates to a cell radio system having a TDMA
structure for transmitting information in time slots,
10 which are brought together to form frames. Each of the
frames has information fields for channel data, test
data, etc, as well as a useful information field.

15 When installing radio systems, in particular
mobile radio systems or cordless telephone systems, it
is necessary to ensure that a user at a certain
geographical location can initiate and maintain a
perfect radio connection to the base station. It is
known that the quality of the radio channel between a
base station and a mobile station is influenced to
20 varying degrees by different factors. Some of these
factors are subject to considerable variations over
time, such as, for example, weather-related influences,
in particular rain and snow, passing vehicles or the
yearly change in the foliage of trees and bushes.

25 A method of this type has become known from German
Patent No. 195 17 393 C1. This document discloses a
method and an arrangement for testing radio channels of
a communications system. In this method, test data is
generated in an identical manner at the base station
30 and the mobile station and is sent to the base station
by the mobile station in the B-channel of the DECT
system (Digital Enhanced Cordless Telecommunications)
and the reception result is compared with the desired
data. In this way, there is obtained a data error
35 rate, which is used together with the channel
parameters also transmitted in the DECT system to

assess the transmission quality of the radio channel.

Although the known method renders possible a very useful assessment of the channel quality, it is a requirement that certain test data is transmitted and that this test data must also be known at the base station. This implies a certain preparation time for the measurement and the corresponding adaptation at the base station.

For a rapid assessment of the channel quality, above all in the case of the DECT system which is here considered as a first priority, hitherto generally only the average value of the received field strength has been measured and established and this value used as a quality criterion for the channel. In the DECT system, this value is termed average RSSI value (Radio Signal Strength Indicator).

The applicant has recognised, however, that in many cases, the average RSSI value is not an adequate means for assessing the channel quality, but that, on the contrary, rapid alterations over time of the signal also have to be observed. This in turn leads to lengthy and expensive examinations of the channel performance at a certain location.

The present invention therefore seeks to develop a method and a device which, during the installation of a radio system, render possible a very rapid, above all time-optimised, determination of the channel quality and require no adaptation at the base station.

According to one aspect of the invention, there is provided a method for testing the transmission quality of a radio channel between a base station and a mobile station in a cell radio system, in which information is transmitted in frames, wherein the received field strength is established periodically and the at least fourth moment M of the field strength measured values, namely

$$M = \sqrt[k]{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^k} \quad \text{with } k \geq 4,$$

5 is formed from a number n of established field strength measured values x_i , and, as a measure of quality, the difference between the average field strength measured value \bar{x} and this moment M is established and checked to see whether this difference lies below a certain
10 limiting value, and if the difference lies below the limiting value, the frame error rate over a specified period is established as an additional measure of quality.

According to a second aspect of the invention,
15 there is provided a method for testing the transmission quality of a radio channel between a base station and a mobile station in a cell radio system, in which the received field strength is established periodically, wherein the frame error rate over a specified period is
20 established and checked to see whether this rate lies above a specified limiting value, and if the frame error rate lies above the limiting value, the at least fourth moment M of the field strength measured values, namely

25

$$M = \sqrt[k]{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^k} \quad \text{with } k \geq 4$$

is formed from a number n of established field strength
30 measured values x_i , and the difference between the average field strength measured value \bar{x} and this moment M is established, as a further measure of quality.

According to a third aspect of the invention,
there is provided an arrangement for testing the
35 transmission quality of a radio channel between a base station and a mobile station in a cell radio system in

which information is transmitted in frames and in which arrangement at least the mobile station is equipped for periodically establishing the received field strength, wherein the mobile station comprises an evaluating unit, to which the field strength measured values are continually supplied and which is equipped for the calculation of an average field strength measured value and also the at least fourth moment from the field strength measured values and for the formation of the difference between the average field strength measured value and the moment, and also for the calculation of a frame error rate from the number of frame errors that is supplied to it.

Thus the invention teaches that either the fourth moment (or a higher one) or the frame error rate is a suitable standard for the assessment of the channel quality, in which case one of the two variables is to be established, and the other variable is to be established only if the first-established result gives rise to doubt about the quality of the channel. In order to make the claims clear, two separate independent method claims each directed to one of the alternatives outlined above has been drafted.

It is furthermore advantageous if the received field strength is periodically established as the peak value of the field strength, which peak value is measured with a specified time constant over at least one TDMA frame.

When determining the channel quality, the fourth moment has proven particularly significant, but a higher moment (for example the sixth or eighth) could also be established. The exemplary embodiment utilising the fourth moment is discussed in the following description, but the invention should not be understood as being limited to the fourth moment.

In most mobile radio systems, an automatic change-

over of the radio channel (handover) is provided. In such a radio system, it is advantageous if as an additional measure of quality, the rate of handover recurrence established over a certain period is established, in which case a time optimisation is possible as a result of the fact that the rate of handover recurrence is taken into account only if the above-mentioned difference lies below a limiting value and the frame error rate lies above a limiting value.

5
10 In mobile radio systems of this type, including the DECT system, if the quality of a certain radio channel drops, the mobile station initiates at the base station a channel (frequency) change-over, wherein the base station, with the aid of the information available to it, actually carries out or does not carry out a handover according to the free channels in each case.

15
20 It has proven advantageous to establish as a further measure of quality for the radio channel the ratio of the number of channel (frequency) change-overs (handovers) that are carried out to the number that are initiated.

25 An arrangement with which the method according to the invention can advantageously be realised is distinguished by the fact that there is allocated to the mobile station an evaluating unit, to which the field strength measured values are continually supplied and which is equipped for the calculation of an average field strength measured value and also the at least fourth moment from the field strength measured values and for the formation of the difference between the average field strength measured value and the moment, and that the evaluating unit is equipped for the calculation of a frame error rate from the number of frame errors that is supplied to it.

30
35 In order to improve the assessment of the channel quality, it can be advantageous if there are supplied

to the evaluating unit signals of the mobile station relating to the number of handovers that are initiated and also the number that are carried out, and said evaluating unit is equipped for the calculation of the rate of handover recurrence from these signals. In this case, it is recommended that the evaluating unit be equipped for the calculation of the ratio of the number of frequency change-overs that are carried out to the number that are initiated.

In order to carry out the measurements in practice, it is advantageous if the evaluating unit is integrated at least partially in the mobile station in terms of software and hardware.

For a better understanding of the present invention, and to show how it may be brought into effect, reference will now be made, by way of example, to the accompanying drawing which shows a block-circuit diagram of an arrangement according to the invention.

The invention is now described with reference to the drawing, with the aid of its realisation in a DECT system. The knowledge of the specialist in this field is assumed and in this respect, by way of example, reference is made to DE 195 17 393 C1, already mentioned in the introduction, and also to: "Struktur des DECT-Standards", by U. Pilger, Nachrichtentechnik Elektronik 42 (1992), January, February, No. 1, Berlin.

The drawing shows a block-circuit diagram of a commercially-available mobile station MT of a cell radio system, in particular of a DECT system. The basic components of a mobile portion of this type are a high-frequency portion HF, a so-called Burst Mode Controller BMC and also a digital signal processor (DSP), which, among other things, takes care of the coding, decoding and compression of the speech, for which a microphone MIC and a loudspeaker LS are provided as electroacoustic transducers. The control

of the modules is taken over by a micro-controller MC,
which is connected to the modules by way of a bus BU.
The micro-controller MC also has an interface ST, for
example for an IIC bus, by way of which data can be
5 transmitted in both directions and by way of which, if
appropriate, the micro-controller MC can also be
influenced.

Like the majority of cell radio systems used at
this time, the DECT system also uses a TDMA structure,
10 the frame of which is subdivided into 24 time slots,
with the first 12 time slots being used for the
transmission from a base station (not shown here) to
the mobile portion and the further 12 time slots being
used for the transmission in the opposite direction.
15 Each 480-bit long time slot is divided into fields, of
which the longest field, the B-field having $320 + 4$
bits, is used for the actual transmission of
information. Other fields are used for data protection
or for the transmission of channel data, for example.
20 Of course the invention can be applied to other systems
in which the information is transmitted in frames.

If a so-called radio-local-loop system is to be
installed, methods, and devices suitable therefor, are
required in order to determine whether a user with a
25 mobile station MT can initiate or participate in a
perfect radio connection under all circumstances which
arise in practice.

In order to obtain for this the suitable criteria
in the shortest possible time, the field strength at
30 the location of the mobile station is measured
periodically, something which is provided anyway in the
DECT system. The mobile station delivers field
strength measured values x_i , which are periodically
established as the peak value of the field strength,
35 which peak value is measured with a predetermined time
constant over at least one TDMA frame. It is known to

average these values, but it has been shown that such an average value, also called RSSI value (Radio-Signal-Strength-Indicator) is not in itself a suitable measure for the assessment of the quality of a radio transmission channel.

The invention provides a much more suitable measure for the assessment of the quality of a radio transmission channel is the fourth moment, namely

$$M = \sqrt[4]{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^4}$$

Apart from the 4th moment, however, higher moments exemplified by, but not limited to, the sixth or eighth moment can also be used successfully. It is admittedly known to calculate the variance of the RSSI values, thus the second moment, but the applicant has found that the variable of the variance does not permit a particularly rapid channel assessment either, neither alone nor in connection with other variables.

Interference of transmitted data is also established by the CRC tests (Cyclic Redundance Check) which are carried out constantly, and in the DECT system, if there are a certain number of CRC errors, the whole information (speech) block is "muted", i.e. all the bits are set to 1. This case is also termed frame error, and the number of faulty or muted frames is made available by the mobile station or is present therein.

In the sense of the invention, the difference between the average field strength measured value \bar{x} and the fourth moment M_4 , i.e. $D = \bar{x} - M_4$, is now established and a check is made to see whether this difference D lies below a certain and specified limiting value D_0 . If this difference does lie below the limiting value D_0 , then furthermore, over a

specified period, the number of frames which are faulty or have been defined as faulty by the system is established, and as an additional measure of quality for the channel quality, the frame error rate r_f is established therefrom.

Such a measurement can also be carried out very rapidly and delivers a meaningful and realistic assessment of the channel quality.

Returning to the drawing, it can be seen that there is provided an evaluating unit AW, which has an interface IF, which is connected by way of the IIC bus to the micro-controller MC of the mobile station MT. Average field strength measured values x_i at the interface IF are, on the one hand, averaged in an averaging unit MWB and result in an average value \bar{x} and, on the other hand, the individual field strength measured values x_i and also the average value \bar{x} are processed in a moment calculator MOB to give the fourth moment or a higher moment. In a subtractor S, the above-mentioned difference $\bar{x}-M$ is formed and supplied to an evaluating/display unit A/A, in which there takes place in a comparator V1 a comparison with the above-mentioned limiting value D_0 . The result can lead to a display or can be processed further. The number of faulted or muted frames is supplied to an error rate calculator FR (frame error rate calculator), which establishes a frame error rate r_f and compares this in a second comparator V2 with a limiting value R_0 for the frame error rate. The output of the second comparator V2 can also lead to a display or be processed further.

It has been described here that first of all the difference D between the average field strength measured value \bar{x} and the fourth moment M_4 is established and compared with a limiting value D_0 , in which case, depending on the output of this comparison, it is then decided whether it is still necessary or advantageous

to take the frame error rate r_f and its comparison with a limiting value R_0 into account. However, the reverse procedure is also possible, i.e. first of all the frame error rate r_f can be established and compared with a limiting value r_0 . If the frame error rate r_f lies below this limiting value, which can, of course, be set from case to case, it can then be assumed that there is a sufficiently good channel quality, so that a further examination of the channel is no longer necessary. If, however, the frame error rate r_f lies above this limiting value, the establishing of the above-mentioned difference $D = \bar{x} - M_4$ can take place as a further measurement, and this difference can be compared with a limiting value D_0 .

Mobile radio systems or cordless systems generally provide an automatic change-over of the radio channel (in the sense of another frequency) if the particular (frequency) channel, for whatever reason, is disturbed. In the DECT system, such a channel change-over, also called handover, is always carried out by the base station at the request of a mobile station. In this connection, it is necessary to distinguish between channel (frequency) change-overs which are initiated on the one hand, and then channel (frequency) change-overs which are actually carried out by the base station on the other hand. In accordance with the invention, this rate of handover recurrence is, when required, also used for the assessment of the channel as an additional measure of quality, with the rate of recurrence of the channel or frequency change-overs (handovers) that are actually carried out being designated y_a in the following, while on the other hand, the designation y_e is used for the rate of recurrence of the handovers that are initiated.

In accordance with the invention, the rate of handover recurrence y_a over a predetermined period is

accordingly taken into account as an additional measure of quality, possibly only if the difference D , mentioned above, lies below the limiting value D_0 and/or the frame error rate r_f lies above a limiting value r_0 .

5 As a further feature which is significant for the channel quality, particularly in doubtful cases, the ratio v of the number of handovers that are carried out to the number that are initiated can be established, in which case these numbers naturally relate to a certain
10 period and thus represent a rate of recurrence. It can be seen from the drawing that the rate of recurrence y_e of the frequency/channel change-overs that are initiated is calculated from the number of initiated handovers, which number is also present at the
15 interface IF, and is then supplied to the evaluating/display unit A/A. In the same way, in a calculating unit BD, the rate of recurrence y_a of handovers that are carried out is calculated from the number of channel change-overs that are actually
20 carried out, and this rate of recurrence is in turn supplied to the evaluating/display unit A/A. The ratio $V = y_a/y_e$ can additionally be calculated in a divider DS and supplied to the evaluating/display unit A/A. The values y_e , y_a and v can result in displays in the
25 evaluating/display unit A/A or, if appropriate, can be processed further with the output data of the comparators V1 and V2 in order to render possible a suitable display of the channel quality.

30 The block-circuit diagram shown in the drawing is primarily intended to clarify the method in accordance with the invention, because it is plausible that this method can essentially be realised in software. Accordingly, it is not even necessary to have an evaluating unit AW which is physically separated from
35 the mobile portion MT; instead, portions of this evaluating unit, or the whole evaluating unit AW, can

be realised in hardware and/or software in the mobile
portion MT. The extent to which this takes place or
can take place depends on the respective construction
and possibly on the computing capacity of the mobile
station MT or its micro-controller MC.

A particular advantage of the invention lies in
that a realistic and extremely rapid assessment of the
channel quality is possible. The base station does not
even need to send random data in the B-field as in the
prior art.

CLAIMS

1. Method for testing the transmission quality of a radio channel between a base station and a mobile station in a cell radio system, in which information is transmitted in frames, wherein the received field strength is established periodically and the at least fourth moment M of the field strength measured values, namely

10
$$M = \sqrt[k]{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^k} \quad \text{with } k \geq 4,$$

is formed from a number n of established field strength measured values x_i , and, as a measure of quality, the difference between the average field strength measured value \bar{x} and this moment M is established and checked to see whether this difference lies below a certain limiting value, and if the difference lies below the limiting value, the frame error rate over a specified period is established as an additional measure of quality.

2. Method for testing the transmission quality of a radio channel between a base station and a mobile station in a cell radio system, in which the received field strength is established periodically, wherein the frame error rate over a specified period is established and checked to see whether this rate lies above a specified limiting value, and if the frame error rate lies above the limiting value, the at least fourth moment M of the field strength measured values, namely

30
$$M = \sqrt[k]{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^k} \quad \text{with } k \geq 4$$

35 is formed from a number n of established field strength measured values x_i , and the difference between the

average field strength measured value \bar{x} and this moment M is established, as a further measure of quality.

3. Method according to claim 1 or 2, wherein the received field strength is periodically established as the peak value of the field strength, which peak value is measured with a specified time constant over at least one frame.

4. Method according to claim 3, wherein the fourth moment ($k = 4$) is established.

5. Method according to one of the claims 1 to 4 in a radio system with automatic change-over of the radio channel, wherein as an additional measure of quality, the rate of handover recurrence is established over a predetermined period.

6. Method according to claim 5, wherein the rate of handover recurrence is taken into account only if the difference lies below a limiting value and the frame error rate lies above a limiting value.

7. Method according to claim 5 or 6, wherein the rate of recurrence of the handovers which are initiated at a base station and also the rate of recurrence of the handovers which are then actually carried out is established, and as a further measure of quality, the ratio of the number of handovers that are carried out to the number that are initiated is established.

8. Arrangement for testing the transmission quality of a radio channel between a base station and a mobile station in a cell radio system in which information is transmitted in frames and in which arrangement at least the mobile station is equipped for periodically establishing the received field strength, wherein the mobile station comprises an evaluating unit, to which the field strength measured values are continually supplied and which is equipped for the calculation of an average field strength measured value and also the at least fourth moment from the field

5 strength measured values and for the formation of the difference between the average field strength measured value and the moment, and also for the calculation of a frame error rate from the number of frame errors that is supplied to it.

10 9. Arrangement according to claim 8, wherein there are supplied to the evaluating unit signals of the mobile station relating to the number of handovers that are initiated and also the number that are carried out, and said evaluating unit is equipped for the calculation of the rate of handover recurrence from these signals.

15 10. Arrangement according to claim 9, wherein the evaluating unit is equipped for the calculation of the ratio (v) from the number of frequency change-overs that are carried out to the number that are initiated.

20 11. Arrangement according to one of the claims 8 to 10, wherein the evaluating unit is integrated at least partially into the mobile station in terms of software and hardware.

12. A method for testing the transmission quality of a radio channel substantially as herein described, with reference to the accompanying drawings.

25 13. A mobile station utilising a method as claimed in one or more of claims 1-7 or 12, and/or including an arrangement as claimed in one of claims 8-11.



Application No: GB 9808077.3
Claims searched: all

Examiner: Nigel Hall
Date of search: 2 October 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:
UK Cl (Ed.P): H4L (LFM)
Int Cl (Ed.6): H04B 1/10, 17/00; H04Q 7/34
Other: Online: INSPEC, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
	NONE	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.